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Awareness about Medicinal application of Copper Nanoparticles among Dental Students

Research Article

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Abstract

Introduction: Nanobiotechnology is a new discipline of science that deals with nanoscale materials in fields including biotechnology, nanotechnology, physics, chemistry, and material science. For the creation of metallic nanoparticles, three primary approaches are used: chemical, physical, and biological. Copper and its compounds have also been employed as effective antibacterial, antifungal, antiviral, and molluscicidal agents, in addition to these uses. Copper nanoparticles have recently gained popularity due to their catalytic, optical, electrical, and antimicrobial properties.
Aim: This survey was conducted for assessing the awareness about medicinal application of copper nanoparticles amongst dental students.
Materials and Method: A cross-section research was conducted with a self-administered questionnaire containing ten questions distributed amongst 100 dental students. The questionnaire assessed the awareness about copper nanoparticles therapy in medical applications, their antibacterial properties, anti-fungal properties, anti-viral properties, anti-cancer activities, mechanism of action and toxicity effects, the responses were recorded and analysed.
Results: 11% of the respondents were aware of the medicinal applications of Copper Nanoparticles. 9 % were aware of antibacterial properties of Copper Nanoparticles, 9 % were aware of anti-fungal properties of Copper Nanoparticles, 7 % were aware of anti-viral properties of Copper Nanoparticles, 5% were aware of, anti-cancer activities of Copper Nanoparticles and, 5% were aware of mechanism of action and toxicity effects, of Copper Nanoparticles.
Conclusion: There is limited awareness amongst dental students about use of Copper nanoparticles therapy in medical applications. Enhanced awareness initiatives and dental educational programmes together with increased importance for curriculum improvements that further promote knowledge and awareness of Copper nanoparticles therapy.

Keywords: Awareness; Copper; Nanoparticles; Students; Medicinal.

Introduction

Nanobiotechnology is a new discipline of science that deals with nanoscale materials in fields including biotechnology, nanotechnology, physics, chemistry, and material science. For the creation of metallic nanoparticles, three primary approaches are used: chemical, physical, and biological [1]. For ages, copper has been used as a biocide. In the 1880s, copper sulphate, lime, and water (Bordeaux mixture) and copper sulphate and sodium carbonate (Burgundy mixture) were employed as potential fungicides for spraying grapes to combat mildew in the United States and France, respectively [1, 2].

Copper and its compounds have also been employed as effective antibacterial, antifungal, antiviral, and molluscicidal agents, in addition to these uses. Copper compounds, however, may be hazardous to fish and other species. It may potentially pose a threat to the ecosystem. As a result, greater doses of direct copper and copper compounds should be avoided. Copper nanoparticles, on the other hand, can be used as a replacement to prevent these problems. Copper nanoparticles have recently gained popularity due to their catalytic, optical, electrical, and antimicrobial properties [3].

Metal nanoparticles such as copper, silver, palladium, platinum, titanium, and others are technologically significant due to their

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optical, electrical, and catalytic capabilities, as well as their applicability in a variety of fields. Due to their powerful antibacterial effects against a wide spectrum of pathogens, including multidrug-resistant species, silver and copper nanoparticles have gained prominence as innovative antimicrobial agents. Because silver is a costly metal, the cost of producing silver nanoparticles is also significant. Copper, on the other hand, is less expensive than silver and is readily available, making the synthesis of copper nanoparticles cost-effective. Copper nanoparticles have the extra benefit of oxidising to generate copper oxide nanoparticles, which are easy to mix with polymers or macromolecules and have reasonably stable chemical and physical properties [4, 5]. Our research experience has prompted us in pursuing this research [6-17]. This survey was conducted for assessing the awareness about medicinal application of Copper nanoparticles amongst dental students.

Materials and Methods

A cross-section research was conducted with a self-administered questionnaire containing ten questions distributed amongst 100 dental students. The questionnaire assessed the awareness about copper nanoparticles therapy in medical applications, their anti-bacterial properties, anti-fungal properties, anti-viral properties, anti-cancer activities, mechanism of action and toxicity effects, the responses were recorded and analysed.

Results

11% of the respondents were aware of the medicinal applications of Copper Nanoparticles (Fig 1). 9 % were aware of anti-bacterial properties of Copper Nanoparticles (Fig 2), 9 % were aware of anti-fungal properties of Copper Nanoparticles (Fig 3), 7 % were aware of anti-viral properties of Copper Nanoparticles (Fig 4), 5% were aware of anti-cancer activities of Copper Nanoparticles (Fig 5) and, 5% were aware of mechanism of action and toxicity effects, of Copper Nanoparticles (Fig 6).

Discussion

Copper nanoparticles have been proven to be efficient against both gram-positive and gram-negative bacteria, in addition to

Figure 1. Awareness of the medicinal applications of Copper Nanoparticles.

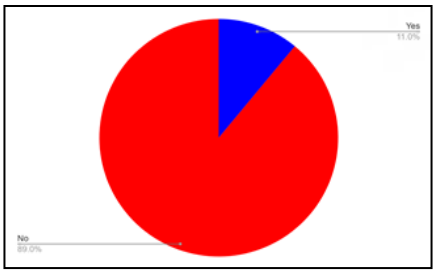


Figure 2. Awareness of anti-bacterial properties of Copper Nanoparticles.

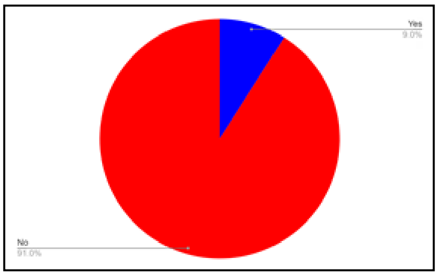


Figure 3. Awareness of anti-fungal properties of Copper Nanoparticles.

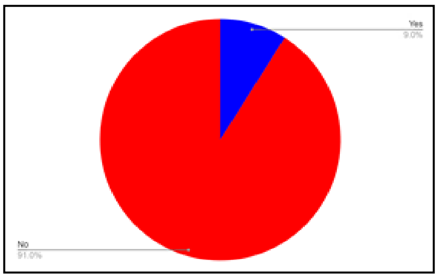


Figure 4. Awareness of anti-viral properties of Copper Nanoparticles.

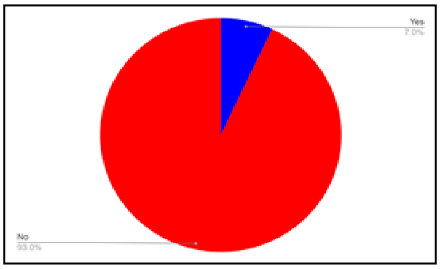


Figure 5. Awareness of, anti-cancer activities of Copper Nanoparticles.

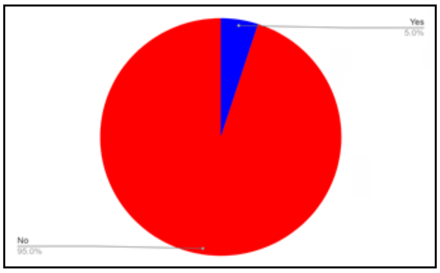
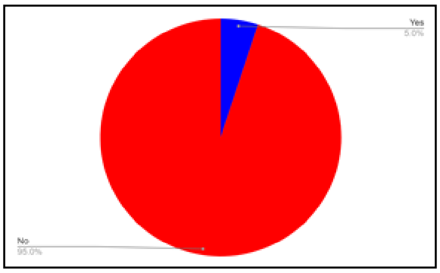


Figure 6. Awareness of mechanism of action and toxicity effects, of Copper Nanoparticles.



controlling yeast and mould growth [18]. Using the Kirby–Bauer diffusion method, Das et al. (2010) investigated the antibacterial activity of copper nanoparticles against three bacteria: Staphylococcus aureus, Bacillus subtilis, and Escherichia coli. Copper nanoparticles were discovered to be excellent growth inhibitors against these bacteria [19]. Copper nanoparticles were found to have promising antibacterial action against Micrococcus luteus, S. aureus, E. coli, Klebsiella pneumoniae, and Pseudomonas aeruginosa in a study by Ramyadevi et al. (2012). E. coli, S. aureus, M. luteus, and K. pneumoniae were the most vulnerable bacteria, while P. aeruginosa was found to be resistant to copper nanoparticles[20].

E. coli and B. subtilis susceptibility to silver and copper nanoparticles was investigated by Yoon et al. (2007). They discovered that when the concentration of nanoparticles increased, the survival rate of bacteria reduced. Silver and copper nanoparticles totally inhibited E. coli and B. subtilis at concentrations more than 70 and 60 g/mL, respectively. Copper nanoparticles were shown to be more effective than silver nanoparticles in this investigation. Copper oxides, meantime, are gaining popularity as antibacterial agents due to their ability to be synthesised with extraordinarily high surface areas and unique crystal morphologies [21]. However, gram-negative organisms were more susceptible to copper nanoparticles in time-kill studies [22].

Copper nanoparticles have also been studied for use in biotechnological applications that could help fight fungal illnesses. Researchers have tried to combine copper nanoparticles with a polymer material to create a composite that may release metal species in a controlled manner, inhibiting the growth of fungus and other pathogenic microbes [23].

Among the different species of fungi, Saccharomyces cerevisiae is said to be a model organism for studying the antifungal activity of nanomaterials [24]. Cu-based zeolites were shown to have fungicidal activity against Cladosporium cladosporoides, Phaeococcomyces chersonesos, and Ulocladium chartarum isolated from marble by Petranovskii et al. Kim et al. used a disc diffusion assay to evaluate antibacterial activity of the Cu–SiO2 nanocomposite against Candida albicans and Penicillium citrinum, and they reported promising action against both fungi [25]. In another study, the antifungal activity of hyper-branched polyamine copper nanoparticles, Cu–SiO2 nanocomposites, SiO2–Cu, and copper-doped hydroxyapatite nanopowders against C. albicans, a pathogenic fungus that causes infections in the mouth, oesophagus, gastrointestinal tract, urinary bladder, and genital tract, was investigated. The results of their research showed that colloidal hyperbranched polyamine/copper nanoparticles suppressed C. albicans development even at a low concentration of 1.4 g/100 L [26].

A few papers on copper nanoparticle antiviral activity are published, confirming that copper nanoparticles have promising antiviral activity. Using a plaque titration experiment, Fujimori et al. examined the antiviral efficacy of nanosized copper iodide particles with an average size of 160 nm against an influenza A virus of swine origin (pandemic [H1N1] 2009). They demonstrated dose-dependent activity on virus titer, with the 50 percent effective concentration for 60 minutes of exposure duration being around 17 g/ml. SDS-PAGE examination later showed the virus's inactivation as a result of viral proteins like hemagglutinin and neuraminidase being degraded by nanosized copper iodide particles. As a result, Fujimori et al. asserted that these nanoparticles could be effective in the construction of filters, face masks, protective apparel, and kitchen towels to defend against viral attacks [27].

Ramyadevi et al. described the chemical synthesis of metallic copper nanoparticles using a polyol technique that used copper acetate as a precursor and Tween 80 as both the medium and the stabilising reagent. They also tested the anti-parasitic properties of copper nanoparticles against hematophagous malaria vector Anopheles subpictus Grassi, filariasis vector Culex quinquefasciatus, and cattle tick Rhipicephalus microplus, Canestrini larvae. Their research found that metallic nanoparticles were harmful to aquatic creatures, owing to particulate impacts rather than the release of dissolved ions [20].

Nanoparticles have a unique capability for drug loading, effective photoluminescence, and targeted administration of imaging agents and anti-cancer therapies, among many other applications. Jose et al. investigated the ability of copper nanoparticles to degrade DNA and their anti-cancer properties. They discovered that copper nanoparticles degrade isolated DNA molecules in a dose-dependent manner by generating singlet oxygen. Copper nanoparticle DNA degradation was prevented using singlet oxygen scavengers such as sodium azide and tris (hydroxyl methyl) aminomethane, showing the participation of activated oxygen species in the degradation process. They also discovered that copper nanoparticles might cause apoptosis in U937 and HeLa cells from human histiocytic lymphoma and human cervical carcinoma, respectively, through generating cytotoxicity [28].

Chang *et al.,* proposed three pathways based on oxidative stress, coordination effects, and nonhomeostasis effects to explain why copper and zinc oxide nanoparticles cause toxicity in eukaryotic cells. Nanoparticles can enter the cell directly through the pores in the cell membrane, or they can enter through ion channels and transporter proteins on the plasma membrane, according to the researchers. Endocytosis allows certain nanoparticles to enter cells. Nanoparticles that penetrate the cell can interact directly with oxidative organelles like mitochondria. Later, redox active proteins increase the development of reactive oxygen species (ROS) in cells, and nanoparticle-produced ions (Cu2+) can cause ROS through a variety of chemical processes. ROS has the ability to cause DNA strand breaks and alter gene expression. Cu2+ ions can also form chelates with biomolecules or dislodge metal ions from certain metalloproteins, resulting in functional protein inactivation. Cu2+ produced by copper oxide nanoparticles raises local concentrations and impairs cellular metal cation homeostasis, leading to cell toxicity [29].

The effect of copper nanoparticles on the rat's dorsal root ganglion (DRG) was investigated by Prabhu *et al.* For 24 hours, these neurons were exposed to copper nanoparticles of varying concentrations (10–100 M) and diameters (40, 60, and 80 nm). When compared to unexposed control cultures, light microscopy, histochemical staining for copper, lactate dehydrogenase assay for cell death, and MTS [3-(4,5- dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide] assay for cell viability revealed a significant toxic effect with all sizes of nanoparticles tested. They also discovered that small-sized nanoparticles with higher concentrations had the most harmful effects [30]. PC12 cells can be employed as model cells for in vitro investigations in neuron research, according to a study by Xu *et al.* They found that increasing concentrations of copper nanoparticles (nano-Cu) and treatment duration reduced PC12 cell viability, showing that cell viability is related to concentration and treatment time. These findings showed that copper nanoparticles are toxic to DRG neurons in rats and PC12 cells in mice in a size and dose dependent way [22]. In another study, it has been reported that CuO nanoparticles induced cytotoxicity in HepG2 cells in a dose-dependent manner [31]. Researchers have claimed that tumor suppressor gene p53 and apoptotic gene caspase-3 were upregulated when exposed to CuO nanoparticles[32].

Conclusion

There is limited awareness amongst dental students about use of Copper nanoparticles therapy in medical applications. Enhanced awareness initiatives and dental educational programmes together with increased importance for curriculum improvements that further promote knowledge and awareness of Copper nanoparticles therapy.

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